SMIC's Solder for ECUs Stands Extreme Temperature

M794-GWS

The automotive industry is now at the transition stage from the conventional internal-combustion engine vehicles to hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), and fuel cell vehicles (FCVs). In order to meet social requirements for safety, comfort, environmental-friendliness, energy savings and increased use of information technologies, the transition from mechanical driving to electric and electronic control, that is, the shift to car electronics, has been advancing. With the shift to car electronics, the varieties and roles of electric control units (ECUs) mounted in a car has become diversified, and the number of ECUs incorporated in a car has also been increasing. In recent years, about 70 ECUs work in a vehicle. Among high-end vehicles include some cars that have more than 100 ECUs. For this reason, the reduction of the number of ECUs, such as the integration of a plurality of ECUs into one ECU, has been carried forward on one hand. At the same time, the expansion of mounting area, such as the installation of ECUs in an engine room or directly on mechanical systems, has been advancing with power train control systems. ECUs have conventionally been installed in vehicle interior, where temperature, humidity, and vibration environments are relatively mild. With the migration of ECUs from the vehicle interior (85°C) to the engine room (115°C) and further, directly on an engine (125°C), temperatures of the environment, to which systems are subject to, have increased. As a result, even smaller and higher-density ECU modules that provide high reliability have been sought.

When temperature differences are added to an ECU, a certain level of thermal displacement develops due to the large differences in thermal expansion between components and substrates. Solder alloys have excellent properties to reduce the thermal stress through plastic deformation and creep deformation. However, the repeated application of thermal stress causes the accumulation of plastic distortion and creep distortion. Then, cracks develop, and eventually the solder alloys are fractured. Hence, temperature cycle characteristics are particularly important for solder alloys used in ECUs mounted on vehicles.

Challenges

Conventional SAC305 lead-free alloy has met thermal resistance fatigability (-40~85°C) required for general consumer electronics. However, it does not withstand the above-mentioned severe environment. This is because automotive ECUs have higher□T compared with consumer electronics. In other words, they are subjected to larger additional stress, and hence, easily plastically deform. In addition, as they are exposed to a high temperature (125°C) coarsening of particles easily occurs and the strength of solder bulk tends to reduce.

Future Prospects

The M794 alloy from Senju Metal Industry Co., Ltd. (SMIC) not only provides electrical reliability with respect to thermal fatigue, but it also can be used using the conventional reflow profile as it has a melting point of 210 to 221°C and a melting temperature region (⊿T) of 11°C. In addition, M794 does not include indium (In), which is easily oxidized, hence, it provides a wide range of choice for the selection of fluxes, including halogen-free fluxes, and air reflow is also possible. ❑

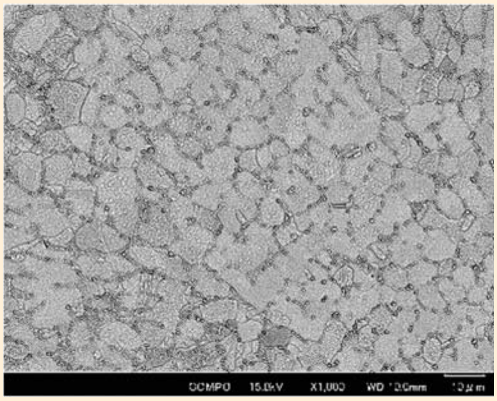
M794 Series

Develop Alloy with Excellent Thermal Fatigue Resistance for On-board ECUs

- High thermal fatigue resistance achieved through precipitation and solid solution strengthening and the addition of trace amounts of elements.
- A wide selection in flux materials, such as halogen-free fluxes. Air reflow is possible
- Growth of cracks is slow, and electrical disconnection due to penetrated cracks is suppressed.

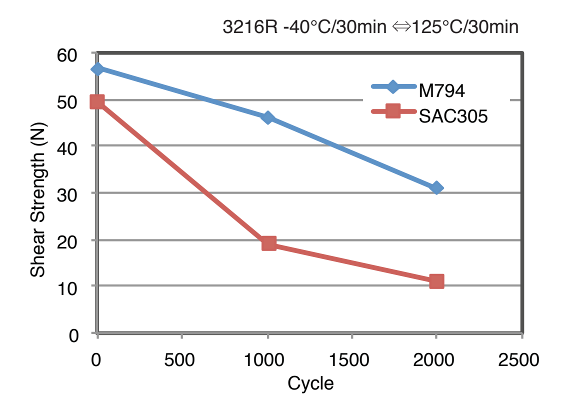
Features

- Bi and Sb solid solution elements are added to Sn-Ag-Cu eutectic composition to improve mechanical strength, and Ni and Co have been added to suppress coarsening.

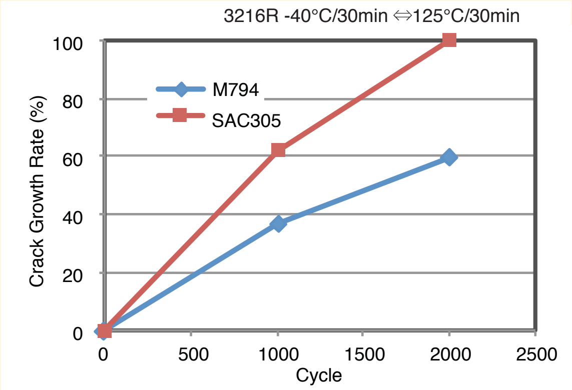


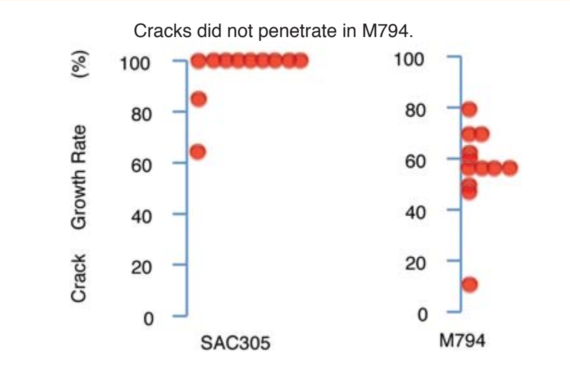
M794 Sn-3.4Ag-0.7Cu-Bi-Sb-Ni-Co

- Comparison of joining strength after thermal shock.



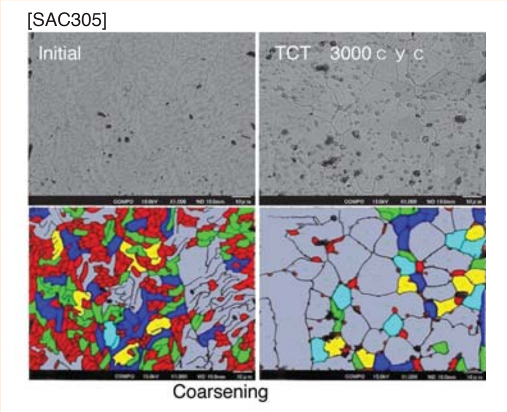
- Comparison of crack growth rate after thermal shock test.



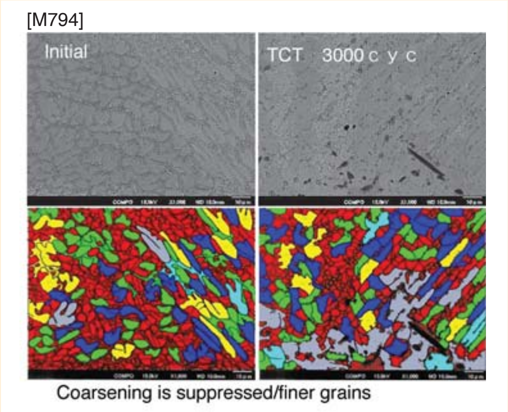


Distribution of crack growth rate after TCT 2000 cycles (n=11)

- Addition of Ni+Co helps suppress coarsening of texture, and blocks the factor for the growth of cracks.



Coarsening



Coarsening is suppressed/finer grains